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APPLICATION
FOR
UNITED STATES LETTERS PATENT

APPLICANT : Grant McFadden and Karim Essani
TITLE : NUCLEIC ACID MOLECULES AND POLYPEPTIDES FOR
IMMUNE MODULATION

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proteins that function to protect the virus from immune recognition and/or clearance by the infected host. Such "subversive" viral proteins are useful therapeutics for the treatment of inflammatory and autoimmune disorders. Poxviruses, in particular, have been a rich source of such immunomodulatory proteins.

The *Yatapoxvirus* genus of poxviruses includes Tanapox virus (TPV), Yaba monkey tumor virus (YMTV), and Yaba-like disease (YLD) virus (Knight *et al.*, *Virology* 172:116-124, 1989). Both TPV and YMTV contain a linear double-stranded, approximately 145 kbp DNA genome (Essani *et al.*, *Microbial Pathogenesis* 17:347-353, 1994; Knight *et al.*, *supra*). TPV produces a mild disease in humans, characterized by transient fever, one or more nodular skin lesions, and regional lymphadenopathy, while YMTV causes benign tumors in monkeys and humans (Paulose *et al.*, *Microbial Pathogenesis* 25:33-41, 1998; Amano *et al.*, *Journal of General Virology* 76:1109-1115, 1995). A 38 kDa secreted glycoprotein from TPV-induced cells has been reported to specifically bind and neutralize three human cytokines, namely interferon- γ , interleukin-2, and interleukin-5 (Essani *et al.*, *supra*).

It would be useful to identify novel viral immunomodulatory genes and polypeptides for the treatment of immunological disorders.

SUMMARY OF THE INVENTION

In general, the present invention provides immunomodulatory gp38 polypeptides, nucleic acid molecules encoding these polypeptides, and therapeutic, diagnostic, and screening methods employing these polypeptides and nucleic acid molecules. The invention also provides methods for identifying compounds that modulate the biological activities of gp38 nucleic acid molecules and polypeptides, and therapeutic methods employing these compounds.

The present invention provides novel *Yatapoxvirus* immunomodulatory gp38 polypeptides, nucleic acid molecules encoding these polypeptides, and therapeutic, diagnostic, and screening methods employing these polypeptides and nucleic acid molecules. The invention also provides methods for identifying
5 compounds that modulate the biological activities of *Yatapoxvirus* gp38 nucleic acid molecules and polypeptides, and therapeutic methods employing these compounds.

In a first aspect, the invention provides a substantially pure *Yatapoxvirus* immunomodulatory polypeptide. In preferred embodiments of the first aspect, the
10 polypeptide can be derived from yaba monkey tumor virus or from tanapox virus. In another preferred embodiment of the first aspect, the polypeptide includes an amino acid sequence that encodes an identifiable signal sequence. In another preferred embodiment of the first aspect, the polypeptide can be a chemokine (e.g. of human interferon- γ , human interleukin-2, and human interleukin-5) binding
15 polypeptide, a cytokine binding polypeptide, an immunomodulator, or an anti-inflammatory polypeptide. In other preferred embodiments of the first aspect, the polypeptide can be glycosylated or have anti-cytokine activity. In other preferred embodiments of the first aspect, the polypeptide may include an amino acid sequence that is substantially identical to the amino acid sequence of SEQ ID NO:
20 1, SEQ ID NO: 2, SEQ ID NO: 4, or SEQ ID NO: 6, or may include the amino acid sequence of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 4, or SEQ ID NO: 6.

In a second aspect, the invention provides a substantially pure *Yatapoxvirus* nucleic acid molecule encoding a *Yatapoxvirus* immunomodulatory polypeptide.
25 In preferred embodiments of the second aspect, the nucleic acid molecule can be genomic DNA, cDNA, or mRNA. In another preferred embodiment of the second aspect, the nucleic acid molecule includes a nucleotide sequence that encodes a polypeptide with an identifiable signal sequence. In other preferred embodiments of the second aspect, the nucleic acid molecule can encode a yaba monkey tumor

virus polypeptide or a tanapox virus polypeptide, encode a polypeptide including an amino sequence that is substantially identical to the amino acid sequence of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 4, or SEQ ID NO: 6, or encode a polypeptide including the amino acid sequence of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 4, or SEQ ID NO: 6. In other preferred embodiments of the second aspect, the nucleic acid molecule can include a nucleotide sequence that is substantially identical to the nucleotide sequence of SEQ ID NO: 3, SEQ ID NO: 5, SEQ ID NO: 7, or SEQ ID NO: 9.

In other preferred embodiments of the second aspect, the invention provides a vector (e.g. a gene therapy vector) including the substantially pure *Yatapoxvirus* nucleic acid molecule encoding a *Yatapoxvirus* immunomodulatory polypeptide, and a cell containing this vector. The *Yatapoxvirus* nucleic acid molecule in the vector can be operably linked to regulatory sequences for expression of a *Yatapoxvirus* polypeptide and the regulatory sequences can include a promoter. The cell can be a human cell, a primate cell, or a rodent cell.

In other preferred embodiments of the second aspect, the invention provides a non-human transgenic animal containing the substantially pure *Yatapoxvirus* nucleic acid molecule encoding a *Yatapoxvirus* immunomodulatory polypeptide, and a cell from the non-human transgenic animal.

In other preferred embodiments of the second aspect, the invention provides a method of detecting a *Yatapoxvirus* gene or a *Yatapoxvirus* gene homolog or fragment thereof in a cell by contacting the substantially pure *Yatapoxvirus* nucleic acid molecule encoding a *Yatapoxvirus* immunomodulatory polypeptide, or a fragment thereof, where the fragment is greater than about 18 nucleotides in length, with a preparation of genomic DNA from the cell, under hybridization conditions providing detection of DNA sequences having about 50% or greater nucleotide sequence identity to SEQ ID NO: 3, SEQ ID NO: 5, SEQ ID NO: 7, or SEQ ID NO: 9.

In a third aspect, the invention provides a nucleic acid molecule having at least 50% nucleic acid sequence identity to a sequence encoding a *Yatapoxvirus* immunomodulatory polypeptide or a fragment thereof, where the fragment includes at least six amino acids and the nucleic acid molecule hybridizes under high stringency conditions to at least a portion of a *Yatapoxvirus* nucleic acid molecule. In a preferred embodiment of the third aspect, the nucleic acid molecule has 100% complementarity to a nucleic acid molecule encoding a *Yatapoxvirus* immunomodulatory polypeptide or a fragment thereof including at least six amino acids, and the nucleic acid molecule hybridizes under high stringency conditions to at least a portion of a *Yatapoxvirus* nucleic acid molecule.

In a fourth aspect, the invention provides a nucleic acid molecule, where the nucleic acid molecule includes a sequence that is antisense to the coding strand of a *Yatapoxvirus* nucleic acid molecule or a fragment thereof.

In a fifth aspect, the invention provides a non-human transgenic animal having a knockout mutation in one or both alleles encoding a polypeptide substantially identical to a *Yatapoxvirus* polypeptide.

In a sixth aspect, the invention provides an antibody that specifically binds to a *Yatapoxvirus* polypeptide, for example, a polypeptide that includes an amino acid sequence that is substantially identical to the amino acid sequence of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 4, or SEQ ID NO: 6. In a preferred embodiment of the sixth aspect, the invention provides a method of detecting a *Yatapoxvirus* polypeptide in a sample by contacting the sample with the antibody, and assaying for the binding of the antibody to the polypeptide.

In a seventh aspect, the invention provides a probe for analyzing a *Yatapoxvirus* gene or a *Yatapoxvirus* gene homolog or fragment thereof, the probe having at least 50% nucleotide sequence identity to a sequence encoding a *Yatapoxvirus* polypeptide or fragment thereof, where the fragment includes at least six amino acids, and the probe hybridizes under high stringency conditions to at least a portion of a *Yatapoxvirus* nucleic acid molecule. In a preferred

embodiment of the seventh aspect, the probe has 100% complementarity to a nucleic acid molecule encoding a *Yatapoxvirus* polypeptide or fragment thereof, where the fragment includes at least six amino acids, and the probe hybridizes under high stringency conditions to at least a portion of a *Yatapoxvirus* nucleic acid molecule.

In an eighth aspect, the invention provides a method of identifying an immunomodulatory *Yatapoxvirus* gene or a *Yatapoxvirus* immunomodulatory gene homolog or fragment thereof by: (a) providing a mammalian cell sample; (b) introducing into the cell sample a candidate gene; (c) expressing the candidate gene; and (d) determining whether the candidate gene elicits an alteration in the level of immune function in the cell sample, where an alteration in the level of immune function identifies the immunomodulatory *Yatapoxvirus* gene or the *Yatapoxvirus* immunomodulatory gene homolog, or fragment thereof.

In a ninth aspect, the invention provides a method for identifying a test compound that modulates the expression or activity of a *Yatapoxvirus* polypeptide, by contacting the *Yatapoxvirus* polypeptide with the test compound, and determining the effect of the test compound on the *Yatapoxvirus* polypeptide expression or activity.

In a tenth aspect, the invention provides a method for identifying a test compound that modulates the expression or activity of a *swinepox* (C1L) polypeptide, by contacting the *swinepox* (C1L) polypeptide with the test compound, and determining the effect of the test compound on the *swinepox* (C1L) polypeptide expression or activity.

In an eleventh aspect, the invention provides a method of targeting proteins for secretion from a cell by attaching an identifiable signal sequence selected from a *Yatapoxvirus* polypeptide to a protein of interest, where the protein of interest is secreted from the cell.

In a twelfth aspect, the invention provides a method of targeting proteins for secretion from a cell by attaching an identifiable signal sequence selected from a *swinepox* (C1L) polypeptide to a protein of interest, where the protein of interest is secreted from the cell.

5 In a thirteenth aspect, the invention provides a method of immunomodulation in a mammal by administering to the mammal a therapeutically effective amount of a *Yatapoxvirus* polypeptide or fragment thereof, where the polypeptide has an immunomodulatory effect in the mammal.

In a fourteenth aspect, the invention provides a method of immunomodulation in a mammal by administering to the mammal a therapeutically effective amount of a *swinepox* (C1L) polypeptide or fragment thereof, where the polypeptide has an immunomodulatory effect in the mammal.

In a fifteenth aspect, the invention provides a method of immunomodulation in a mammal by administering to the mammal a therapeutically effective amount of a compound that modulates the activity of a *Yatapoxvirus* polypeptide, where the compound has an immunomodulatory effect in the mammal.

In a sixteenth aspect, the invention provides a method of immunomodulation in a mammal by administering to the mammal a therapeutically effective amount of a compound that modulates the activity of a *swinepox* (C1L) polypeptide, where the compound has an immunomodulatory effect in the mammal.

The immunomodulation of the thirteenth through sixteenth aspects can be immunosuppression, immunostimulation, cell proliferation, apoptosis, decreasing T cell stimulation, or decreasing inflammation in a mammal.

In an eighteenth aspect, the invention provides a method of treating a mammal having an immunomodulatory disorder, by administering to the mammal a therapeutically effective amount of a compound that modulates the activity of a

swinepox (C1L) polypeptide, where the compound has an immunomodulatory effect in the mammal.

In a nineteenth aspect, the invention provides a pharmaceutical composition including at least one dose of a therapeutically effective amount of a *Yatapoxvirus* polypeptide or fragment thereof, in a pharmaceutically acceptable carrier, the composition being formulated for the treatment of an immunomodulatory disorder.

In a twentieth aspect, the invention provides a pharmaceutical composition including at least one dose of a therapeutically effective amount of a *swinepox* (C1L) polypeptide or fragment thereof, in a pharmaceutically acceptable carrier, the composition being formulated for the treatment of an immunomodulatory disorder.

In preferred embodiments of the thirteenth to twentieth aspects, the *Yatapoxvirus* polypeptide includes an amino acid sequence substantially identical to the amino acid sequence of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 4, SEQ ID NO: 6, or SEQ ID NO: 8, and fragments and analogs thereof.

In other preferred embodiments of the thirteenth to twentieth aspects, the mammal is a human. In other preferred embodiments of the thirteenth to twenty-first aspects, the mammal has a condition selected from the group consisting of acute inflammation, rheumatoid arthritis, transplant rejection, asthma, inflammatory bowel disease, uveitis, restenosis, multiple sclerosis, psoriasis, wound healing, lupus erythematosus, allergic rhinitis, atopic dermatitis, food allergies, type 1 insulin-dependent diabetes mellitus, deramatitis, meningitis, thrombotic thrombocytopenic purpura, Sjogren's syndrome, encephalitis, leukocyte adhesion deficiency, rheumatic fever, Reiter's syndrome, psoriatic arthritic, progressive systemic sclerosis, primary biliary cirrhosis, pemphigus, pemphigoid, necrotizing vasculitis, mayasthenia gravis, lupus erythmatosus, polymyositis, sarcoidosis, granulomatorsis, vasculitis, pernicious anemia, CNS inflammatory disorder, antigen-antibody complex mediated diseases, autoimmune hemolytic anemia, Hashimoto's thyroiditis, Graves disease, habitual spontaneous

abortions, Reynard's syndrome, glomerulonephritis, dermatomyositis, chronic active hepatitis, celiac disease, autoimmune complications of AIDS, atrophic gastritis, ankylosing spondylitis, Addison's disease, psoriasis, penphigus vulgaris, Behcet's syndrome, acute respiratory distress syndrome (ARDS), ischemic heart disease, atherosclerosis, post-dialysis syndrome, leukemia, acquired immune deficiency syndrome septic shock, lipid histiocytosis, and cancer.

In twenty-first and twenty-second aspects, the invention provides a kit for the analysis of a *Yatapoxvirus* nucleic acid molecule, the kit including a nucleic acid molecule probe for analyzing a *Yatapoxvirus* nucleic acid molecule present in a test subject, or including an antibody for analyzing a *Yatapoxvirus* polypeptide present in a test subject.

The invention provides several advantages. For example, it provides methods and reagents that can be used in the diagnosis and treatment of immune diseases that are sensitive to the bioactivities of *Yatapoxvirus* or *swinepox* (C1L) gp38 polypeptides. Other features and advantages of the invention will be apparent from the detailed description of the invention, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an alignment of partial amino acid sequences of gp38 from tanapox virus (SEQ ID NO: 1) and yaba monkey tumor virus (SEQ ID NO: 2).

Figure 2 shows a partial amino acid sequence (SEQ ID NO: 2) and partial open reading frame nucleotide sequence (SEQ ID NO: 3) of gp38 from yaba monkey tumor virus (YMTV).

Figure 3 shows the amino acid sequence of gp38 polypeptide from tanapox virus (SEQ ID NO: 4).

Figure 4 shows the nucleic acid sequence of gp38 from tanapox virus (SEQ ID NO: 5).

Figure 5 shows the amino acid sequence of gp38 polypeptide from yaba-like disease virus (YLDV) (SEQ ID NO: 6).

Figure 6 shows the nucleic acid sequence of gp38 from yaba-like disease virus (YLDV) (SEQ ID NO: 7).

5 **Figure 7** shows the amino acid sequence of gp38 polypeptide from *swinepox* virus (C1L) (SEQ ID NO: 8).

Figure 8 shows the nucleic acid sequence of gp38 from *swinepox* virus (C1L) (SEQ ID NO: 9).

10 **Figure 9** shows the sequence similarity of the various polypeptide amino acid sequences.

DETAILED DESCRIPTION OF THE INVENTION

15 The invention provides gp38 polypeptides and in *swinepox* polypeptide, which play a role in immunomodulation, nucleic acid molecules encoding these polypeptides, and therapeutic and diagnostic methods employing these polypeptides and nucleic acid molecules. The invention also provides methods for identifying compounds that modulate the biological activities of gp38 and *swinepox* nucleic acid molecules and polypeptides, and therapeutic methods
20 employing these compounds.

25 "Polypeptide" or "polypeptide fragment" means a chain of two or more amino acids, regardless of any post-translational modification (*e.g.*, glycosylation, acetylation, or phosphorylation), constituting all or part of a naturally or non-naturally occurring polypeptide. By "post-translational modification" is meant any change to a polypeptide or polypeptide fragment during or after synthesis. Post-translational modifications can be produced naturally (such as during synthesis within a cell) or generated artificially (such as by recombinant or chemical means). A "protein" can be made up of one or more polypeptides.

"*Yatapoxvirus* gp38 immunomodulatory polypeptide" or "*Yatapoxvirus* gp38 polypeptide" means a *Yatapoxvirus* gp38 polypeptide or protein having immunomodulatory activity that is substantially identical to the polypeptide sequences described herein, or a biologically-active fragment or analog thereof.

5 *Yatapoxviruses* have been described in, for example, Essani *et al.* (*Microbial Pathogenesis* 17:347-353, 1994), Knight *et al.* (*Virology* 172:116-124, 1989), Paulose *et al.* (*Microbial Pathogenesis* 25:33-41, 1998), and Amano *et al.* (*Journal of General Virology* 76:1109-1115, 1995), herein incorporated by reference. Specifically included in the invention are Yaba monkey tumor virus
10 (YMTV) and tanapox virus (TPV) gp38 polypeptides.

A *Yatapoxvirus* gp38 polypeptide may also be defined as encoding a polypeptide with at least 50%, preferably at least 75%, more preferably at least 90%, and most preferably at least 95% of the biological activity, *e.g.*, immunomodulatory or anti-inflammatory activity, compared to a reference
15 *Yatapoxvirus* gp38 polypeptide having an amino acid sequence substantially identical to those described herein. The term *Yatapoxvirus* gp38 polypeptide includes homologs, *e.g.*, mammalian homologs of *Yatapoxvirus* gp38 proteins as well as allelic variations, natural mutants, induced mutants, proteins encoded by DNAs that hybridize to the *Yatapoxvirus* gp38 sequences described herein under
20 high stringency conditions, and polypeptides or proteins specifically-bound by antisera directed to a *Yatapoxvirus* gp38 polypeptide. The term also includes chimeric polypeptides that include a *Yatapoxvirus* gp38 fragment.

"*Swinepox* virus (C1L) gp38 immunomodulatory polypeptide" or "*swinepox* virus (C1L) gp38 polypeptide" means a *swinepox* virus (C1L) gp38
25 polypeptide or protein having immunomodulatory activity that is substantially identical to the polypeptide sequences described herein, or a biologically-active fragment or analog thereof.

A *swinepox* virus (C1L) gp38 polypeptide may also be defined as encoding a polypeptide with at least 50%, preferably at least 75%, more preferably at least

90%, and most preferably at least 95% of the biological activity, *e.g.*, immunomodulatory or anti-inflammatory activity, compared to a reference *swinepox* virus (C1L) gp38 polypeptide having an amino acid sequence substantially identical to those described herein. The term *swinepox* virus (C1L) gp38 polypeptide includes homologs, *e.g.*, mammalian homologs of *swinepox* virus (C1L) gp38 proteins as well as allelic variations, natural mutants, induced mutants, proteins encoded by DNAs that hybridize to the *swinepox* virus (C1L) gp38 sequences described herein under high stringency conditions, and polypeptides or proteins specifically-bound by antisera directed to a *swinepox* virus (C1L) gp38 polypeptide. The term also includes chimeric polypeptides that include a *swinepox* virus (C1L) gp38 fragment.

By "biologically-active fragment" is meant a polypeptide fragment of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide that exhibits immunomodulatory properties that are at least 30%, preferably at least 50%, more preferably at least 75%, and most preferably at least 95% of the immunomodulatory properties of a full length *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide. As used herein, the term "fragment" means at least 10 contiguous amino acids, preferably at least 30 contiguous amino acids, more preferably at least 50 contiguous amino acids, and most preferably at least 60 to 80 or more contiguous amino acids. Fragments of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 proteins can be generated by methods known to those skilled in the art or may result from normal protein processing (*e.g.*, removal of amino acids from the nascent polypeptide that are not required for biological activity or removal of amino acids by alternative mRNA splicing or alternative protein processing events).

By "analog" is meant any substitution, addition, or deletion in the amino acid sequence of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide that exhibits properties that are at least 30%, preferably at least 50%, more preferably at least 75%, and most preferably at least 95% of the immunomodulatory

properties of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide from which it is derived. Analogs can differ from the naturally occurring *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein by amino acid sequence differences, by post-translational modifications, or by both. Analogs of the invention are

5 substantially identical to a naturally occurring *Yatapoxvirus* or *swinepox* virus (C1L) gp38 sequence. Modifications include *in vivo* and *in vitro* chemical derivatization of polypeptides, *e.g.*, acetylation, carboxylation, phosphorylation, or glycosylation. Such modifications may occur during polypeptide synthesis or processing or following treatment with isolated modifying enzymes. Analogs can

10 also differ from the naturally occurring *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide by alterations in primary sequence. These include genetic variants, both natural and induced (for example, resulting from random mutagenesis by irradiation or exposure to ethanemethylsulfate or by site-specific mutagenesis as described in Sambrook, Fritsch and Maniatis, *Molecular Cloning:*

15 *A Laboratory Manual* (2d ed.), CSH Press, 1989, hereby incorporated by reference; or Ausubel *et al.*, *Current Protocols in Molecular Biology*, John Wiley & Sons, New York, 1994, hereby incorporated by reference). Also included are cyclized peptides molecules and analogs that contain residues other than L-amino acids, *e.g.*, D-amino acids or non-naturally occurring or synthetic amino acids.

20 Fragments and analogs can be generated using standard techniques, for example, solid phase peptide synthesis or polymerase chain reaction.

"*Yatapoxvirus* gp38 nucleic acid molecule" means a nucleic acid molecule, such as a genomic DNA, cDNA, or RNA (*e.g.*, mRNA) molecule that encodes a polypeptide having the characteristics or biological activities of any *Yatapoxvirus*

25 gp38 polypeptide described herein, or a fragment or analog thereof. A *Yatapoxvirus* gp38 nucleic acid molecule is substantially identical to a reference *Yatapoxvirus* gp38 nucleic acid molecule, as described herein.

"*Swinepox* virus (C1L) gp38 nucleic acid molecule" means a nucleic acid molecule, such as a genomic DNA, cDNA, or RNA (*e.g.*, mRNA) molecule that

encodes a polypeptide having the characteristics or biological activities of any *swinepox* virus (C1L) gp38 polypeptide described herein, or a fragment or analog thereof. A *swinepox* virus (C1L) gp38 nucleic acid molecule is substantially identical to a reference *swinepox* virus (C1L) gp38 nucleic acid molecule, as
5 described herein.

The term "identity" is used herein to describe the relationship of the sequence of a particular nucleic acid molecule or polypeptide to the sequence of a reference molecule of the same type. For example, if a polypeptide or nucleic acid molecule has the same amino acid or nucleotide residue at a given position,
10 compared to a reference molecule to which it is aligned, there is said to be "identity" at that position. The level of sequence identity of a nucleic acid molecule or a polypeptide to a reference molecule is typically measured using sequence analysis software with the default parameters specified therein, such as the introduction of gaps to achieve an optimal alignment (*e.g.*, Sequence Analysis
15 Software Package of the Genetics Computer Group, University of Wisconsin Biotechnology Center, 1710 University Avenue, Madison, WI 53705, BLAST, or PILEUP/PRETTYBOX programs). These software programs match identical or similar sequences by assigning degrees of identity to various substitutions, deletions, or other modifications. Conservative substitutions typically include
20 substitutions within the following groups: glycine, alanine, valine, isoleucine, and leucine; aspartic acid, glutamic acid, asparagine, and glutamine; serine and threonine; lysine and arginine; and phenylalanine and tyrosine.

A nucleic acid molecule or polypeptide is said to be "substantially identical" to a reference molecule if it exhibits, over its entire length, at least 50%
25 or 55% identity, preferably at least 60%, 65%, or 68% identity, more preferably at least 75% or 85% identity, and most preferably at least 90%, 95%, or 99% identity to the sequence of the reference molecule. For polypeptides, the length of comparison sequences is at least 16 amino acids, preferably at least 20 amino acids, more preferably at least 25 amino acids, and most preferably at least

35 amino acids. For nucleic acid molecules, the length of comparison sequences is at least 50 nucleotides, preferably at least 60 nucleotides, more preferably at least 75 nucleotides, and most preferably at least 110 nucleotides.

Alternatively, or additionally, two nucleic acid sequences are "substantially identical" if they hybridize under high stringency conditions. By "high stringency conditions" is meant conditions that allow hybridization comparable with the hybridization that occurs using a DNA probe of at least 500 nucleotides in length, in a buffer containing 0.5 M NaHPO₄, pH 7.2, 7% SDS, 1 mM EDTA, and 1% BSA (fraction V), at a temperature of 65°C, or a buffer containing 48% formamide, 4.8X SSC, 0.2 M Tris-Cl, pH 7.6, 1X Denhardt's solution, 10% dextran sulfate, and 0.1% SDS, at a temperature of 42°C. (These are typical conditions for high stringency northern or Southern hybridizations.) High stringency hybridization is also relied upon for the success of numerous techniques routinely performed by molecular biologists, such as high stringency PCR, DNA sequencing, single strand conformational polymorphism analysis, and *in situ* hybridization. In contrast to northern and Southern hybridizations, these techniques are usually performed with relatively short probes (*e.g.*, usually 16 nucleotides or longer for PCR or sequencing and 40 nucleotides or longer for *in situ* hybridization). The high stringency conditions used in these techniques are well known to those skilled in the art of molecular biology, and examples of them can be found, for example, in Ausubel *et al.*, *Current Protocols in Molecular Biology*, John Wiley & Sons, New York, NY, 1998, which is hereby incorporated by reference.

By "probe" or "primer" is meant a single-stranded DNA or RNA molecule of defined sequence that can base pair to a second DNA or RNA molecule that contains a complementary sequence ("target"). The stability of the resulting hybrid depends upon the extent of the base pairing that occurs. This stability is affected by parameters such as the degree of complementarity between the probe and target molecule, and the degree of stringency of the hybridization conditions.

The degree of hybridization stringency is affected by parameters such as the temperature, salt concentration, and concentration of organic molecules, such as formamide, and is determined by methods that are well known to those skilled in the art. Probes or primers specific for *Yatapoxvirus* gp38 nucleic acid molecules, preferably, have greater than 45% sequence identity, more preferably at least 55-75% sequence identity, still more preferably at least 75-85% sequence identity, yet more preferably at least 85-99% sequence identity, and most preferably 100% sequence identity to the nucleic acid sequences encoding the amino acid sequences described herein. Probes can be detectably-labeled, either radioactively or non-radioactively, by methods that are well-known to those skilled in the art. Probes can be used for methods involving nucleic acid hybridization, such as nucleic acid sequencing, nucleic acid amplification by the polymerase chain reaction, single stranded conformational polymorphism (SSCP) analysis, restriction fragment polymorphism (RFLP) analysis, Southern hybridization, northern hybridization, *in situ* hybridization, electrophoretic mobility shift assay (EMSA), and other methods that are well known to those skilled in the art. A molecule, *e.g.*, an oligonucleotide probe or primer, a gene or fragment thereof, a cDNA molecule, a polypeptide, or an antibody, can be said to be "detectably-labeled" if it is marked in such a way that its presence can be directly identified in a sample. Methods for detectably-labeling molecules are well known in the art and include, without limitation, radioactive labeling (*e.g.*, with an isotope, such as ^{32}P or ^{35}S) and nonradioactive labeling (*e.g.*, with a fluorescent label, such as fluorescein).

"Identifiable signal sequence" means a sequence of amino acids that may be identified by homology, or biological activity, to a peptide sequence with the known function of targeting a polypeptide to a particular region of the cell. Preferably the signal sequence directs the polypeptide to the cellular membrane such that the polypeptide is secreted. Alternatively, the signal sequence may direct the polypeptide to an intracellular compartment or organelle, such as the Golgi apparatus. One of ordinary skill in the art can identify a signal sequence by

using readily available software (e.g., Sequence Analysis Software Package of the Genetics Computer Group, University of Wisconsin Biotechnology Center, 1710 University Avenue, Madison, WI 53705, BLAST, or PILEUP/PRETTYBOX programs). An identifiable signal sequence can be one that is, for example,
5 substantially identical to a sequence that results in cleavage between amino acids 17 and 18 of YMTV gp38 (SEQ ID NO: 2).

By a "substantially pure polypeptide" is meant a polypeptide (or a fragment or analog thereof) that has been separated from proteins and organic molecules that naturally accompany it. Typically, a polypeptide is substantially pure when it
10 is at least 60%, by weight, free from the proteins and naturally-occurring organic molecules with which it is naturally associated. Preferably, the polypeptide is a *Yatapoxvirus* gp38 polypeptide that is at least 75%, more preferably at least 90%, and most preferably at least 99%, by weight, pure. A substantially pure *Yatapoxvirus* gp38 polypeptide can be obtained, for example, by extraction from a
15 natural source (e.g., an infected mammalian cell), by expression of a recombinant nucleic acid molecule encoding a *Yatapoxvirus* gp38 polypeptide, or by chemical synthesis. Purity can be measured by any appropriate method, e.g., by column chromatography, polyacrylamide gel electrophoresis, or HPLC analysis.

A polypeptide is substantially free of naturally associated components
20 when it is separated from those proteins and organic molecules that accompany it in its natural state. Thus, a protein that is chemically synthesized or produced in a cellular system different from the cell in which it is naturally produced is substantially free from its naturally associated components. Accordingly, substantially pure polypeptides not only include those derived from eukaryotic
25 organisms, but also those synthesized in expression systems, for example, *E. coli* or other prokaryotes, yeast, or insect cells.

"Substantially pure nucleic acid molecule" means a nucleic acid molecule that is free of the components that naturally accompany it. For example, a substantially pure DNA is free of the genes that, in the naturally-occurring genome

of the organism from which the DNA of the invention is derived, flank the gene. The term therefore includes, for example, a recombinant DNA which is incorporated into a vector; into an autonomously replicating plasmid or virus; or into the genomic DNA of a prokaryote or eukaryote; or that exists as a separate molecule (e.g., a cDNA or a genomic or cDNA fragment produced by PCR or restriction endonuclease digestion) independent of other sequences. It also includes a recombinant DNA that is part of a hybrid gene encoding additional polypeptide sequence.

A nucleic acid molecule that is "antisense," means a nucleic acid molecule having a sequence that is complementary to at least 75 nucleotides, and preferably at least 100, 150, or 200 nucleotides, of the coding strand of a gene or nucleic acid molecule, such as a *Yatapoxvirus* gp38 gene or nucleic acid molecule. An antisense nucleic acid molecule can be, for example, capable of preferentially lowering the production of a *Yatapoxvirus* gp38 polypeptide encoded by a *Yatapoxvirus* gp38 gene or nucleic acid molecule.

By "vector" is meant a genetically engineered plasmid or virus, derived from, for example, a bacteriophage, adenovirus, retrovirus, poxvirus, herpesvirus, or artificial chromosome, that is used to transfer a polypeptide (e.g., a *Yatapoxvirus* gp38 polypeptide) coding sequence, operably linked to a promoter, into a host cell, such that the encoded peptide or polypeptide is expressed within the host cell. A vector may be a gene therapy vector, i.e., a vector designed to transfer genetic material into the cells of a patient for a therapeutic benefit.

Vectors generally contain regulatory sequences, including promoters, operably linked to the polypeptide coding sequences. A "promoter" is a minimal nucleic acid sequence element sufficient to direct transcription. If desired, constructs of the invention can include promoter elements that are sufficient to render promoter-dependent gene expression controllable in a cell type-specific, tissue-specific, or temporal-specific manner, or inducible by external signals or agents. Such elements can be located in the 5', 3', or intron regions of a gene.

Sequences are "operably linked" when a gene and one or more regulatory sequences are connected in such a way as to permit gene expression when the appropriate molecules (*e.g.*, transcriptional activator proteins) are bound to the regulatory sequences.

5 By a "transgene" is meant a DNA molecule that is inserted by artifice into a cell (*e.g.*, the nuclear genome of a cell), and is incorporated into the genome of an organism that develops from the cell. Such a transgene can be partly or entirely heterologous (*i.e.*, foreign) to the transgenic organism, or can be a gene that is homologous to an endogenous gene of the organism. An organism or animal (*e.g.*,
10 a mammal, such as a mouse, rat, pig, or goat) can be said to be "transgenic" if it developed from a cell that had a transgene inserted into it by artifice.

By a "knockout mutation" is meant an artificially-induced alteration in a nucleic acid molecule (created by recombinant DNA technology or deliberate exposure to a mutagen) that reduces the biological activity of the polypeptide
15 normally encoded therefrom by at least 80% relative to the unmutated gene. The mutation can be, without limitation, an insertion, deletion, frameshift mutation, or a missense mutation. A "knockout animal" is preferably a mammal, and more preferably a mouse, containing a knockout mutation, as defined above.

An antibody is said to "specifically bind" to a polypeptide if it recognizes
20 and binds the polypeptide (*e.g.*, a *Yatapoxvirus* polypeptide), but does not substantially recognize and bind other molecules (*e.g.*, non-*Yatapoxvirus* gp38-related polypeptides) in a sample, *e.g.*, a biological sample, that naturally includes the polypeptide. A preferred antibody binds to any *Yatapoxvirus* gp38 polypeptide sequence that is substantially identical to the polypeptide sequences shown herein,
25 or fragments thereof.

By "sample" is meant a tissue biopsy, amniotic fluid, cell, blood, serum, urine, stool, or other specimen obtained from a patient or test subject. The sample can be analyzed to detect a mutation in a *Yatapoxvirus* gp38 gene, expression levels of a *Yatapoxvirus* gp38 gene or polypeptide, or the biological function of a

particular immunomodulator. "Immunostimulation" refers to a increase in the overall immunoreactivity of the immune system upon administration of an immunomodulator in comparison to the immunoreactivity of an immune system that has not been contacted with the particular immunomodulator. "Decreasing T cell stimulation" means lowering the level of T cell stimulation as measured by, for example, a chromium release assay. "Decreasing inflammation" means decreasing the number of inflammatory cells (leukocytes, for example eosinophils) in the target tissue by, preferably, two-fold. By "cell proliferation" is meant the growth or reproduction of similar cells. By "apoptosis" is meant the process of cell death where a dying cell displays a set of well-characterized biochemical hallmarks which include cytolemmal blebbing, cell soma shrinkage, chromatin condensation, and DNA laddering.

"Immunomodulator" refers to an agent that induces an immunomodulatory effect or alteration (*i.e.*, immunosuppression, immunostimulation, *etc.*) as measured, for example, by an alteration of virulence in mutated viruses or a variety of immunoassays well known in the art (for example, chemotaxis assays as described herein). For example, in the present invention, an immunomodulator may elicit an altered level of immune function, such that the alteration in the level of immune function identifies a *Yatapoxvirus* gp38 polypeptide. An "anti-inflammatory" agent is an immunomodulatory agent capable of decreasing the overall inflammation or immune function upon administration to an individual.

Preferably, the increase or decrease is by at least 10%, preferably by at least 20%, more preferably by at least 50%, still more preferably by at least 75%, yet more preferably by at least 95% and most preferably by at least 100% relative to an untreated control organism, sample, or molecule.

By "immunomodulatory disorder" or "immunological disorder" is meant any pathophysiological condition (*i.e.*, a disturbance of function and/or structure of a living organism, resulting from an external source, a genetic predisposition, a physical or chemical trauma, or a combination of the above, including, but not

limited to, any mammalian disease) that is characterized by an alteration in immune function.

The alteration may include, for example, a decrease in immune cell number or size, an increase in cell apoptosis or death, or a decrease in immune cell growth, survival or differentiation. Immunological disorders include any disease that involve the immune response or immunity in general. More specifically, such a disorder is a malfunction of the immune system that reduces the ability of an organism to resist foreign substances in the body (*e.g.*, viruses, bacteria, bacterial toxins, plant pollen, fungal spores, animal danders, medications, foods, or allogeneic or xenogeneic transplanted organs) or causes the body to produce antibodies against its own tissues (*e.g.*, autoimmune disorders), resulting in tissue injury, or causes cancer. Immunological disorders can also occur when a malfunctioning immune system (caused by, for example, genetic defect, illness, injury, malnutrition, or medications, such as those used for chemotherapy) results in an increase in frequency or severity of infections. Immunological disorders are often accompanied by inflammation, which is the body's reaction to tissue injury, and results in the accumulation of white blood cells, macrophages, and lymphocytes at the site of injury.

Immunological or immunomodulatory disorders include, without limitation, acute inflammation, rheumatoid arthritis, transplant rejection, asthma, inflammatory bowel disease, uveitis, restenosis, multiple sclerosis, psoriasis, wound healing, lupus erythematosus, and any other autoimmune or inflammatory disorder that can be recognized by one of ordinary skill in the art.

For example, other diseases related to inflammation that may be treated by methods the present invention include, but are not limited to, allergic rhinitis, atopic dermatitis and food allergies. Examples of other autoimmune disorders, where the immune system attacks the host's own tissues, include, but are not limited to, type 1 insulin-dependent diabetes mellitus, dermatitis, meningitis, thrombotic thrombocytopenic purpura, Sjogren's syndrome, encephalitis,

leukocyte adhesion deficiency, rheumatic fever, Reiter's syndrome, psoriatic
arthritic, progressive systemic sclerosis, primary biliary cirrhosis, pemphigus,
pemphigoid, necrotizing vasculitis, myasthenia gravis, systemic lupus
erythmatosus, polymyositis, sarcoidosis, granulomatosis, vasculitis, pernicious
5 anemia, CNS inflammatory disorder antigen-antibody complex mediated diseases,
autoimmune hemolytic anemia, Hashimoto's thyroiditis, Graves disease, habitual
spontaneous abortions, Reynard's syndrome, glomerulonephritis,
dermatomyositis, chronic active hepatitis, celiac disease, autoimmune
complications of AIDS, atrophic gastritis, ankylosing spondylitis and Addison's
10 disease. Other diseases related to non-malignant or immunological-related cell-
proliferative diseases that may be treated by methods of the present invention
include psoriasis, pemphigus vulgaris, Behcet's syndrome, acute respiratory
distress syndrome (ARDS), ischemic heart disease, atherosclerosis, post-dialysis
syndrome, leukemia, acquired immune deficiency syndrome septic shock and
15 other type of acute inflammation, lipid histiocytosis, and cancer.

By "test compound" is meant a chemical, be it naturally-occurring or
artificially-derived, that is assayed for its ability to act as an immunomodulator by
employing one of the assay methods described herein or known in the art. Test
compounds may include, for example, peptides, polypeptides, synthesized organic
20 molecules, naturally occurring organic molecules, nucleic acid molecules, and
components thereof.

"Therapeutically effective amount" as used herein in reference to dosage of
a medication, refers to the administration of a specific amount of a
pharmacologically active agent (*e.g.*, a *Yatapoxvirus* gp38 polypeptide as
25 described herein) tailored to each individual patient manifesting symptoms
characteristic of an immunological disorder, or at risk for a immunological
disorder. For example, a patient receiving the treatment of the present invention
might be experiencing an autoimmune or inflammatory disease. A person skilled
in the art will recognize that the optimal dose of a pharmaceutical agent to be

administered will vary from one individual to another. Dosage in individual patients should take into account the patient's height, weight, rate of absorption and metabolism of the medication in question, the stage of the disorder to be treated, and what other pharmacological agents are administered concurrently.

5 By "pharmaceutically acceptable carrier" is meant a carrier that is physiologically acceptable to the treated mammal while retaining the therapeutic properties of the compound with which it is administered. One exemplary pharmaceutically acceptable carrier is physiological saline solution. Other physiologically acceptable carriers and their formulations are known to one skilled
10 in the art and described, for example, in *Remington: The Science and Practice of Pharmacy*, (19th edition), ed. A. Gennaro, 1995, Mack Publishing Company, Easton, PA.

By "treating " or "treatment" is meant the medical management of a patient with the intent to cure, ameliorate, stabilize, or prevent a disease, pathological
15 condition, or disorder. This term includes active treatment, that is, treatment directed specifically toward the improvement or associated with the cure of a disease, pathological condition, or disorder, and also includes causal treatment, that is, treatment directed toward removal of the cause of the associated disease, pathological condition, or disorder. In addition, this term includes palliative
20 treatment, that is, treatment designed for the relief of symptoms rather than the curing of the disease, pathological condition, or disorder; preventative treatment, that is, treatment directed to minimizing or partially or completely inhibiting the development of the associated disease, pathological condition, or disorder; and supportive treatment, that is, treatment employed to supplement another specific
25 therapy directed toward the improvement of the associated disease, pathological condition, or disorder. The phrase "treatment" also includes symptomatic treatment, that is, treatment directed toward constitutional symptoms of the associated disease, pathological condition, or disorder.

By "cytokine" is meant a small molecular weight polypeptide that plays an important role in regulating the immune response, by for example, signaling adjacent cells. By "chemokine" is meant a small molecular weight ligand that is a chemoattractant for leukocytes (*e.g.*, neutrophils, basophils, monocytes, and T cells), and is important for infiltration of lymphocytes and monocytes into sites of inflammation.

The therapeutic, diagnostic, and screening methods of the invention are first described, followed by general approaches that can be used in carrying out these methods. This description will assist those skilled in the art to better understand the invention and its principles and advantages. It is intended that this description be illustrative of the invention and not limit the scope thereof.

Therapeutic Methods Employing gp38 Nucleic Acid Molecules, Polypeptides, Antibodies, And Immunomodulatory Compounds

The invention includes methods of treating or preventing immunological disorders by using immunomodulatory agents. Immunomodulatory reagents include, without limitation, *Yatapoxvirus* gp38 or *swinepox* virus (C1L) polypeptides; *Yatapoxvirus* or *swinepox* virus (C1L) gp38 cDNAs, mRNAs, or antisense RNAs; *Yatapoxvirus* or *swinepox* virus (C1L) gp38 antibodies; and any compound that modulates *Yatapoxvirus* gp38 biological activity, expression, or stability.

Yatapoxvirus or *swinepox* virus (C1L) gp38 polypeptides identified in the present invention (or fragments or analogs thereof) that exhibit anti-cytokine activity, anti-inflammatory activity, and exhibit a decrease in leukocyte chemotaxis activity are considered particularly useful in the invention; such polypeptides may be used, for example, as therapeutics to decrease the immunoreactivity in a individual with rheumatoid arthritis. Other immunological disorders that may be treated using an immunosuppressive agent, or an agent that reduces the immune function, include acute inflammation, allergic reactions,

asthmatic reactions, inflammatory bowel diseases (*i.e.*, Crohn's Disease and ulcerative colitis), transplant rejection, and restenosis. Alternatively, a polypeptide that enhances or induces apoptosis may be used in the treatment of tumors.

5 Treatment or prevention of diseases resulting from an immunomodulatory disorder is accomplished, for example, by modulating the function of a immunoregulatory protein by delivering a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein to the appropriate cells. It is also possible to correct an immune defect by modifying the physiological pathway (*e.g.*, a signal transduction pathway), in which the immunoregulatory protein participates, by delivering a
10 *Yatapoxvirus* gp38 protein or nucleic acid molecule to the appropriate cells.

Direct administration of a recombinant *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein, nucleic acid molecule, antibody, or compound, either to the site of a potential or actual disease-affected tissue (for example, by injection), or
15 systemically for treatment of, for example, an autoimmune or inflammatory disorder, can be performed accordingly to any conventional recombinant protein administration technique known in the art or described herein. The actual dosage depends on a number of factors known to those of ordinary skill in the art, including the size and health of the individual patient, but generally, between
20 0.1mg and 100mg inclusive are administered per day to an adult in any pharmaceutically-acceptable formulation.

A *Yatapoxvirus* or *swinepox* virus (C1L) gp38 immunomodulator, antiinflammatory agent, or anticarcinogen may be administered with a pharmaceutically-acceptable diluent, carrier, or excipient, at a pharmaceutically
25 effective dose. Conventional pharmaceutical practice may be employed to provide suitable formulations or compositions to administer *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptides to patients suffering from an immunomodulatory disorder. Any appropriate route of administration may be employed, for example, parenteral, intravenous, subcutaneous, intramuscular, intracranial, intraorbital,

ophthalmic, intraventricular, intracapsular, intraspinal, intracisternal, intraperitoneal, intranasal, aerosol, or oral administration. Therapeutic formulations may be in the form of liquid solutions or suspensions; for oral administration, formulations may be in the form of tablets or capsules; and for intranasal formulations, in the form of powders, nasal drops, or aerosols.

Methods well known in the art for making formulations are found in, for example, "Remington's Pharmaceutical Sciences, *supra*." Formulations for parenteral administration may, for example, contain excipients, sterile water, or saline, polyalkylene glycols such as polyethylene glycol, oils of vegetable origin, or hydrogenated naphthalenes. Biocompatible, biodegradable lactide polymer, lactide/glycolide copolymer, or polyoxyethylene-polyoxypropylene copolymers may be used to control the release of the compounds. Other potentially useful parenteral delivery systems for *Yatapoxvirus* gp38 immunomodulatory compounds include ethylene-vinyl acetate copolymer particles, osmotic pumps, implantable infusion systems, and liposomes. Formulations for inhalation may contain excipients, for example, lactose, or may be aqueous solutions containing, for example, polyoxyethylene-9-lauryl ether, glycocholate and deoxycholate, or may be oily solutions for administration in the form of nasal drops, or as a gel.

Yatapoxvirus or *swinepox* virus (C1L) gp38 Gene Therapy

A *Yatapoxvirus* or *swinepox* virus (C1L) gp38 gene or fragment thereof can be used in immunomodulatory or anti-cancer gene therapy. For example, to enhance leukocyte infiltration of a tumor, a functional *Yatapoxvirus* or *swinepox* virus (C1L) gp38 gene or fragment thereof may be introduced into cells at the site of a tumor. In addition, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptides that are shown to reverse autoimmune reactions can also be used in gene therapy. Alternatively, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptides that block inflammation can be administered via gene therapy, for example, for the treatment of eosinophil-mediated inflammatory conditions.

Gene transfer is achieved using viral vectors, as well as by non-viral means. Transplantation of genes into the affected tissues of a patient can also be accomplished by transferring a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 gene or fragment thereof into a cultivatable cell type *ex vivo*, after which the cell (or its

5 descendants) is injected into a targeted tissue.

Retroviral vectors, adenoviral vectors, adeno-associated viral vectors, or other viral vectors with the appropriate tropism for *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein-expressing cells may be used as a gene transfer delivery system for a therapeutic *Yatapoxvirus* or *swinepox* virus (C1L) gp38 gene

10 construct. Numerous vectors useful for this purpose are known (see, for example, Miller, *Human Gene Therapy* 15-14, 1990; Friedman, *Science* 244:1275-1281, 1989; Eglitis and Anderson, *BioTechniques* 6:608-614, 1988; Tolstoshev and Anderson, *Current Opinion in Biotechnology* 1:55-61, 1990; Sharp, *The Lancet* 337:1277-1278, 1991; Cornetta *et al.*, *Nucleic Acid Research and Molecular*

15 *Biology* 36:311-322, 1987; Anderson, *Science* 226:401-409, 1984; Moen, *Blood Cells* 17:407-416, 1991; and Miller and Rosman, *Biotechniques* 7:980-990, 1989; Le Gal La Salle *et al.*, *Science* 259:988-990, 1993; and Johnson, *Chest* 107:77S-83S, 1995). Retroviral vectors are particularly well developed and have been used in clinical settings (Rosenberg *et al.*, *N. Engl. J. Med* 323:370, 1990; Anderson *et*

20 *al.*, U.S. Pat. No. 5,399,346).

Non-viral approaches, for the introduction of therapeutic DNA into cells, include transfection *in vitro*, by means of any standard technique, including but not limited to, calcium phosphate, DEAE dextran, electroporation, protoplast fusion, and liposomes. For example, a *Yatapoxvirus* gp38 gene may be introduced

25 into a tumor cell by lipofection (Felgner *et al.*, *Proc. Natl. Acad. Sci. USA* 84:7413, 1987; Ono *et al.*, *Neuroscience Lett* 117:259, 1990; Brigham *et al.*, *Am. J. Med. Sci.* 298:278, 1989; Staubinger and Papahadjopoulos, *Meth. Enz.* 101:512, 1983); asialorosonucoid-polylysine conjugation (Wu and Wu, *J. Biol. Chem.*

263:14621, 1988; Wu *et al.*, *J. Biol. Chem.* 264:16985, 1989); or microinjection under surgical conditions (Wolff *et al.*, *Science* 247:1465, 1990).

For any of the above approaches, the therapeutic *Yatapoxvirus* gp38 DNA construct is preferably applied to the site of the malignancy or inflammation and cytotoxic damage (for example, by injection), but may also be applied to tissue in the vicinity of the malignancy or inflammation and cytotoxic damage, or even to a blood vessel supplying these areas.

In the gene therapy constructs, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 cDNA expression is directed from any suitable promoter (*e.g.*, the human cytomegalovirus, simian virus 40, or metallothionein promoters), and its production is regulated by any desired mammalian regulatory element. For example, if desired, enhancers known to direct preferential gene expression in endothelial or epithelial cells may be used to direct *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein expression. Such enhancers include, without limitation, the lung specific promoters (*e.g.* surfactant), and gut specific regulatory sequences.

Alternatively, if a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 genomic clone is utilized as a therapeutic construct (for example, following its isolation by hybridization with a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 cDNA), *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein expression is regulated by its cognate regulatory sequences or, if desired, by regulatory sequences derived from a heterologous source, *e.g.*, any of the promoters or regulatory elements described herein.

Yatapoxvirus or *swinepox* virus (C1L) gp38 gene therapy is also accomplished by direct administration of the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 mRNA to a tumor. This mRNA may be produced and isolated by any standard technique, but is most readily produced by *in vitro* transcription using a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 cDNA under the control of a high efficiency promoter (*e.g.*, the T7 promoter). Administration of *Yatapoxvirus* or

swinepox virus (C1L) gp38 mRNA to malignant cells is carried out by any of the methods for direct nucleic acid administration described above.

Transgenic Animals

- 5 Transgenic animals may be made using standard techniques (see for example, Gene Targeting: A Practical Approach, A. L. Joyner, ed., Oxford University Press, 1999). For example, a *Yatapoxvirus* gp38 gene may be provided using endogenous control sequences or using constitutive, tissue-specific, or inducible regulatory sequences. Transgenic animals lacking functional
- 10 *Yatapoxvirus* or *swinepox* virus (C1L) gp38 homolog polypeptide may also be made using standard techniques. This may be done by engineering knock-out mutations in the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 homolog gene using DNA sequences provided herein.

15 *Yatapoxvirus Knockouts*

- Poxviruses are among the largest eukaryotic DNA viruses and have the unusual capacity to replicate autonomously in the cytoplasm of infected cells. Many poxvirus proteins have been defined as virulence factors on the basis that, when present, they confer increased pathogenicity and improve viral replication
- 20 within immunocompetent hosts. When genes that encode these virulence factor proteins are deleted, the resulting virus strain generally exhibits an attenuated or altered disease phenotype (Turner, *Curr. Top. Microbiol. Immunol.*, 163:125-151, 1990; Buller, *Microbiol. Rev.*, 55:80-122, 1991; Smith, *J. Gen. Virol.*, 74:1725-1740; McFadden, Austin (TX): R. G. Landes Company, 1995, incorporated herein
- 25 by reference). Such "knockout" *Yatapoxviruses* may assist in the elucidation of the immunomodulatory or other role of viral proteins.

Using standard virological assays (*e.g.*, Nash *et al.*, (1999) Immunological Review, 57:731), one of ordinary skill in the art may establish the contribution of each gene to *Yatapoxvirus* infection and the general biochemical and physiological

progression of viral infection. Knockout *Yatapoxviruses* lacking a particular gene may be generated using standard molecular biological techniques (see Sambrook *et al.*, *supra*; Innis *et al.*, *PCR Protocols: A Guide to Methods and Applications*, Academic Press, San Diego, CA, 1990; Erlich *et al.*, *PCR Technology: Principles and Applications for DNA Amplification*, Stockton Press, New York, NY, 1989 each of which is incorporated herein by reference). The virulence of these knockout viruses may be assessed using standard infectivity assays well known in the art (see Nash *et al.*, *supra*). For example, as mentioned above, the gp38 polypeptide of *Yatapoxviruses* (SEQ ID NOs: 1 or 2) can be useful in elucidating the mechanism used by *Yatapoxviruses* and other poxviruses to inhibit inflammation.

Diagnostic Methods Employing *Yatapoxvirus* or *swinepox virus* (C1L) gp38 Nucleic Acid Molecules, Polypeptides, and Antibodies

Yatapoxvirus or *swinepox virus* (C1L) gp38 polypeptides and nucleic acid molecules can be used in the detection or monitoring of inflammatory, autoimmune, and other conditions. For example, because *Yatapoxvirus* or *swinepox virus* (C1L) gp38 proteins may be involved in leukocyte chemotaxis, and because a decrease in the number of leukocytes correlates with immunosuppression, an alteration in the level of particular *Yatapoxvirus* or *swinepox virus* (C1L) gp38 protein production provides an indication of the prognosis of the condition. Levels of *Yatapoxvirus* or *swinepox virus* (C1L) gp38 protein expression may be assayed by any standard technique. For example, its expression in a biological sample (*e.g.*, a biopsy) may be monitored by standard Northern blot analysis or may be aided by PCR (see, *e.g.*, Ausubel *et al.*, *supra*; Yap and McGee, *Nucl. Acids. Res.* 19:4294, 1991).

In yet another approach, immunoassays are used to detect or monitor *Yatapoxvirus* or *swinepox virus* (C1L) gp38 protein in a biological sample. *Yatapoxvirus* gp38 protein-specific polyclonal or monoclonal antibodies

(produced as described herein) may be used in any standard immunoassay format (e.g., ELISA, Western blot, or RIA assay) to measure *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide levels. A change in *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein production may be indicative of a particular prognosis.

5 Examples of immunoassays are described, e.g., in Ausubel *et al.*, *supra*.

Immunohistochemical techniques may also be utilized for *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein detection. For example, a tissue sample may be obtained from a patient, and a section stained for the presence of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein using an anti-*Yatapoxvirus* or *swinepox*

10 virus (C1L) gp38 protein antibody and any standard detection system (e.g., one which includes a secondary antibody conjugated to horseradish peroxidase).

General guidance regarding such techniques can be found in, e.g., Bancroft and Stevens (*Theory and Practice of Histological Techniques*, Churchill Livingstone, 1982) and Ausubel *et al.* (*supra*).

15
Identification Of Molecules That Modulate *Yatapoxvirus* or *swinepox* virus (C1L) gp38 Biological Activity Or Whose Biological Activity Is Modulated By *Yatapoxvirus* or *swinepox* virus (C1L) gp38 Virus

20 Isolation of the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 nucleic acid molecule sequence also facilitates the identification of molecules that increase or decrease a *Yatapoxvirus* gp38 or *swinepox* virus (C1L) polypeptide biological activity. Similarly, molecules whose activity is modulated by a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide biological activity can be identified.

25 These molecules can be tested using assays described herein, e.g., chemotaxis assays. A molecule which promotes an increase in *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein expression or a decrease in leukocyte chemotaxis activity is considered particularly useful in the invention; such a molecule may be used, for example, as a therapeutic to decrease the immunoreactivity in an individual.

According to one approach, candidate molecules are added at varying concentrations to the culture medium of cells expressing *Yatapoxvirus* or *swinepox* virus (C1L) gp38 mRNA. *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide biological activity is then measured using standard techniques. The measurement of biological activity can include the measurement of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide protein and nucleic acid molecule levels, or the effect of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide on immunomodulation

If desired, the effect of candidate modulators on expression can, in the alternative, be measured at the level of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein production using the same general approach and standard immunological detection techniques, such as western blotting or immunoprecipitation with a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide-specific antibody (see below).

Candidate modulators can be purified (or substantially purified) molecules or can be one component of a mixture of compounds (*e.g.*, an extract or supernatant obtained from cells; Ausubel *et al.*, *supra*). In a mixed compound assay, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide expression is tested against progressively smaller subsets of the candidate compound pool (*e.g.*, produced by standard purification techniques, *e.g.*, HPLC or FPLC) until a single compound or minimal compound mixture is demonstrated to modulate *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide expression.

Alternatively, or in addition, candidate compounds can be screened for those that modulate *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide activity. In this approach, the level of immunomodulation in the presence of a candidate compound is compared to the level of immunomodulation in its absence, under equivalent conditions. Again, such a screen can begin with a pool of candidate compounds, from which one or more useful modulator compounds is isolated in a step-wise fashion.

The screening assays described above can be carried out in a variety of ways that are well known to those skilled in this art. These include using *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide variants or by using fragments of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide.

5 A test compound that can be screened in the methods described above can be a chemical, be it naturally-occurring or artificially-derived. Such compounds can include, for example, polypeptides, synthesized organic molecules, naturally occurring organic molecules, nucleic acid molecules, and components thereof. Candidate *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide modulators
10 include peptide as well as non-peptide molecules (*e.g.*, peptide or non-peptide molecules found, *e.g.*, in a cell extract, mammalian serum, or growth medium in which mammalian cells have been cultured).

In general, novel drugs for prevention or treatment of immunomodulatory diseases are identified from large libraries of both natural products, synthetic (or
15 semi-synthetic) extracts, and chemical libraries using methods that are well known in the art. Those skilled in the field of drug discovery and development will understand that the precise source of test extracts or compounds is not critical to the screening methods of the invention. Accordingly, virtually any number of chemical extracts or compounds can be screened using these methods. Examples
20 of such extracts or compounds include, but are not limited to, plant-, fungal-, prokaryotic-, or animal-based extracts, fermentation broths, and synthetic compounds, as well as modifications of existing compounds.

Numerous methods are also available for generating random or directed synthesis (*e.g.*, semi-synthesis or total synthesis) of any number of chemical
25 compounds, including, but not limited to, saccharide-, lipid-, peptide-, and nucleic acid molecule-based compounds. Synthetic compound libraries are commercially available from Brandon Associates (Merrimack, NH) and Aldrich Chemical (Milwaukee, WI). Alternatively, libraries of natural compounds in the form of bacterial, fungal, plant, and animal extracts are commercially available from a

number of sources, including Biotics (Sussex, UK), Xenova (Slough, UK), Harbor Branch Oceanographic Institute (Ft. Pierce, FL), and PharmaMar, U.S.A.

(Cambridge, MA). In addition, natural and synthetically produced libraries are produced, if desired, according to methods known in the art, *e.g.*, by standard
5 extraction and fractionation methods. Furthermore, if desired, any library or compound can be readily modified using standard chemical, physical, or biochemical methods.

In addition, those skilled in the art of drug discovery and development readily understand that methods for dereplication (*e.g.*, taxonomic dereplication,
10 biological dereplication, and chemical dereplication, or any combination thereof) or the elimination of replicates or repeats of materials already known for their therapeutic activities for immunological disorders can be employed whenever possible.

When a crude extract is found to regulate immunomodulation, further
15 fractionation of the positive lead extract can be carried out to isolate chemical constituents responsible for the observed effect. Thus, the goal of the extraction, fractionation, and purification process is the careful characterization and identification of a chemical entity within the crude extract having a desired activity. The same assays described herein for the detection of activities in
20 mixtures of compounds can be used to purify the active component and to test derivatives thereof. Methods of fractionation and purification of such heterogenous extracts are known in the art. If desired, compounds shown to be useful agents for treatment are chemically modified according to methods known in the art. Compounds identified as being of therapeutic value can be
25 subsequently analyzed using, for example, any of the animal models described herein.

The above approaches may also be used to inhibit the activity of the candidate compound by substituting an altered *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide having *Yatapoxvirus* or *swinepox* virus (C1L) gp38

protein blocking activity (e.g., have a deletion or insertion at the amino terminus) for the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide described above.

Animal Models

5 Immunomodulators of this invention and other compounds found to be effective at the level of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein expression or activity are tested in animal models, for efficacy in treating, for example, autoimmune and inflammatory diseases and cancer.

10 Animal models for testing the immunomodulatory effects of candidate compounds are well known in the art. Therefore, the present invention refers to a selection of animal models that can be used to test the candidate compounds of the invention. Animal models proposed for use in the present invention to test candidate compounds for their efficacy in treating autoimmune and inflammatory disorders include, but are not limited to:

15 *Acute inflammation:*

20 Animal models of acute inflammation are targeted for initial and rapid drug efficacy screening, and for their potential predicative value of outcomes in chronic inflammatory diseases. The following animal models can be used to test the candidate compounds of the present invention for their efficacy in treating acute inflammation: 1) carrageenin-induced inflammation model; 2) turpentine-induced inflammation model; 3) transgenic HLAB-27 inflammation model; and 4) ear-scratch model of inflammation.

25 *Rheumatoid arthritis: rat, mouse, rabbit*

Efficacy in Rheumatoid Arthritis evaluated in: 1) various antigen-induced arthritis models in rabbit, rat, and mouse; and 2) in transgenic rheumatological models.

The molecular and cellular mechanisms of action of the candidate compounds are evaluated by testing their efficacy in influencing key intracellular mechanisms that regulate degradative processes involved in joint disease.

Important molecular and cellular mechanisms that receive particular attention

- 5 include signaling events regulating disease processes such as increased angiogenesis, synovial hyperplasia, and matrix metalloprotease expression. These processes have been implicated in cartilage degradation in arthritic diseases.

1. Collagen-induced arthritis: rat, mouse, rabbit

- 10 Autoimmune-mediated polyarthritis can be induced in certain strains of rodents (rat, mouse and rabbit) and non-human primates by immunizing them with native type II collagen. The collagen-induced arthritis model is widely used and well characterized. Collagen-induced arthritis is mediated by susceptibility to autoantibodies which bind to a particular region of type II collagen. The
15 mechanism of induction is linked to MHC-class II molecules but also depends on the species of type II collagen used for immunization.

2. Ovalbumin-induced arthritis; rabbit

- 20 Candidate compounds are tested for efficacy in decreasing signs and symptoms of ovalbumin arthritis. Polyarthritis is induced in rabbits by immunizing them with Ovalbumin.

3. Adjuvant-induced arthritis: rat, mouse, rabbit

- 25 Candidate compounds are tested for the efficacy in decreasing signs and symptoms of adjuvant-induced arthritis. Polyarthritis is induced in certain strains of rodents by immunizing them with Freud's Adjuvant.

4. Streptococcal cell wall-induced arthritis: rat

Candidate compounds are tested for efficacy in decreasing signs and symptoms of streptococcal cell wall-induced arthritis. Chronic, erosive polyarthritis is induced by intraperitoneal injection of an aqueous suspension of cell wall fragments isolated from group A streptococci.

5

Transplant rejection (acute and chronic)

Efficacy in transplant rejection is evaluated in various models of graft vascular disease (GVD). GVD is the most common cause of late graft failure in solid organ transplantation. GVD or graft atherosclerosis is characterized by plaque formation and fibrosis in small vessels. The development of graft vascular disease has been associated with acute allograft rejection, ischemia-reperfusion injury, and bacterial or viral infections. The common pathway of these postoperative insults results in perivascular inflammation which triggers migration of mesenchymal cells into the vessel wall, eventually resulting in occlusion or partial occlusion of the vessel lumen.

10

15

1. *Aortic allograft model: rat, rabbit, monkey*

Candidate compounds are tested for efficacy in reducing graft atherosclerosis and transplant rejection in a model of vascular injury after transplantation of aortic segments performed in certain strains of MHC mismatched rats, monkeys, and rabbits.

20

2. *Tracheal allograft model: rat, rabbit, monkey*

Candidate compounds are tested for efficacy in reducing graft atherosclerosis and transplant rejection in a model of vascular injury after transplantation of tracheal segments performed in certain strains of MHC mismatched rats, rabbits, and monkeys.

25

3. Heterotopic heart transplant: mouse, rat, monkey

A heterotopic heart transplantation is performed in MHC mismatched animals. In this model, animals are treated with cyclosporine A for only the first 7 days after transplantation are allowed to develop graft vascular disease, and are then analyzed after sacrifice at postoperative day 90.

4. Orthotopic kidney transplant: mouse, rat, monkey

An orthotopic kidney transplantation is performed in MHC mismatched animals. In this model, animals receiving subtherapeutic doses of cyclosporine A for the first 10 days after transplantation are allowed to exhibit features of chronic renal allograft rejection in 70% of cases, and are then analyzed after sacrifice at postoperative day 90.

5. Orthotopic lung transplant: rat, monkey

Candidate compounds are tested for effectiveness in delaying or reducing signs and symptoms of organ rejection after lung whole organ transplantation in rats and monkeys.

6. Reperfusion injury: rat

The immediate postoperative course in clinical lung transplantation is often severely impaired by delayed graft function as a result of ischemia and reperfusion injury. Preventive efficacy of drug candidates in ischemia-reperfusion injury is evaluated using a model of acute *in vivo* double lung transplantation in the rat (Hausen *et al.*, *Ann. Thorac. Surg.* 61:1714-9, 1996 incorporated herein by reference).

Restenosis

Candidate compounds are tested for efficacy in reducing atherosclerotic plaque deposition in a model of coronary restenosis after balloon angioplasty.

Atherosclerotic plaque formation is critically involved in vascular occlusion and has been linked to excessive inflammatory and thrombotic response to arterial injury.

5 *Asthma: rodent*

The effectiveness of candidate compounds in reduction of signs and symptoms of asthma is evaluated in rodent models of antigen-induced experimental airways inflammation. The models include:

10 1. Ovalbumin-induced experimental airways inflammation: rodent

Candidate compounds are tested for efficacy in reducing inflammatory cell components in the bronchoalveolar lavage of the lungs after aerosol challenge in ovalbumin-sensitized rodent models of experimental airways inflammation.

15 2. Ovalbumin-induced allergic sensitization in presence of GM-CSF transgene expression: mice

Candidate compounds are tested for efficacy in reducing inflammatory cell components in the bronchoalveolar lavage of the lungs of mice after ovalbumin aerosol challenge in the context of local expression of GM-CSF (Staempfli *et al.*, *J. Clin. Invest.*, Vol. 102:9, 1704-1714).

Inflammatory bowel disease (IBD): mice and rats

Drug candidates are evaluated for their potential therapeutic efficacy in ulcerative colitis or Crohn's disease utilizing various models of antigen-induced and genetically-mediated spontaneous chronic intestinal inflammation in mice and rats. Examples include:

1. Dextran sulfate sodium induced IBD: mice

Chronic, irreversible clinical symptoms of IBD are induced by treating mice with an oral administration of dextran sulfate sodium.

2. Gene deletion and transgenic models for IBD: rodent

Compound efficacy will be tested in transgenic rodent lines which develop symptoms closely resembling the human elements of inflammatory bowel disease. Models include, the targeted deletion of the genes encoding IL-2, IL-10, TGF beta, T-cell receptor alpha/beta, keratin 8, Gi2 alpha. In addition, animals expressing transgenes for the human WA-B27 and HLA-B27 as well as a dominant negative construct which functionally blocks N-cadherin will be tested.

Uveitis

Drug candidates will be evaluated for efficacy in various animal models of uveitis. Key models include both, experimental autoimmune uveitis and adoptively transferred experimental autoimmune uveitis.

1. Experimental autoimmune uveitis (EAU)

EAU is a T-cell mediated inflammatory eye disease that can be induced in several mammalian species by immunization with ocular-specific antigens (Gery *et al.*, *Invest. Ophthalmol. Vis. Sci.*, 27: 1296-1300, 1986,. Sanui *et al.*, *J. Exp. Med.*, 169:1947-1989, incorporated herein by reference). This experimental disease is considered a model for a family of inflammatory eye diseases in humans and has been used to examine numerous modalities before their human testing.

2. Adoptively transferred experimental autoimmune uveitis

Adoptively transferred EAU is induced through injection of lymphocytes presensitized against the retinal antigen are injected into naive syngenic recipients

(McAllister *et al.*, *J. Immunol.*, 138:1416-1420, 1987 incorporated herein by reference)

Yatapoxvirus or *swinepox* virus (C1L) gp38 Protein Expression

5 In general, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 may be produced by transformation or transfection of a suitable host cell with all or part of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein-encoding cDNA fragment in a suitable expression vehicle.

10 Those skilled in the field of molecular biology will understand that any of a wide variety of expression systems may be used to provide the recombinant protein. The precise host cell used is not critical to the invention. The *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein may be produced in a prokaryotic host (*e.g.*, *E. coli*) or in a eukaryotic host (yeast cells, *e.g.*, *Saccharomyces cerevisiae*, insect cells, *e.g.*, Sf21 cells, or mammalian cells, *e.g.*, COS 1, NIH 3T3, or HeLa cells). Such cells are available from a wide range of sources (*e.g.*, the American Type Culture Collection, Rockland, MD; also, see, *e.g.*, Ausubel *et al.*, *supra*). The method of transformation or transfection and the choice of expression vehicle will depend on the host system selected. Transformation and transfection methods are described, *e.g.*, in Ausubel *et al.* (20 *supra*); expression vehicles may be chosen from those provided, *e.g.*, in *Cloning Vectors: A Laboratory Manual*, P.H. Pouwels *et al.*, 1985, Supp. 1987).

 One preferred expression system is the baculovirus system (using, for example, the vector pBacPAK9) available from Clontech (Pal Alto, CA). If desired, this system may be used in conjunction with other protein expression techniques, for example, the myc tag approach described by Evan *et al.* (*Mol. Cell Biol.* 5:3610-3616, 1985).

 Alternatively, a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein is produced by a stably-transfected mammalian cell line. A number of vectors suitable for stable transfection of mammalian cells are available to the public, *e.g.*,

see Pouwels *et al.* (*supra*); methods for constructing such cell lines are also publicly available, *e.g.*, in Ausubel *et al.* (*supra*). In one example, cDNA encoding the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein is cloned into an expression vector which includes the dihydrofolate reductase (DHFR) gene.

- 5 Integration of the plasmid and, therefore, the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein-encoding gene into the host cell chromosome is selected for by inclusion of 0.01-300 mM methotrexate in the cell culture medium (as described in Ausubel *et al.*, *supra*). This dominant selection can be accomplished in most cell types. Recombinant protein expression can be increased by DHFR-
- 10 mediated amplification of the transfected gene. Methods for selecting cell lines bearing gene amplifications are described in Ausubel *et al.* (*supra*); such methods generally involve extended culture in medium containing gradually increasing levels of methotrexate. DHFR-containing expression vectors commonly used for this purpose include pCVSEII-DHFR and pAdD26SV(A) (described in Ausubel *et*
- 15 *al.*, *supra*). Any of the host cells described above or, preferably, a DHFR-deficient CHO cell line (*e.g.*, CHO DHFR⁻ cells, ATCC Accession No. CRL 9096) are among the host cells preferred for DHFR selection of a stably-transfected cell line or DHFR-mediated gene amplification.

- 20 Once the recombinant *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein is expressed, it is isolated, *e.g.*, using affinity chromatography. In one example, an anti-*Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein antibody (*e.g.*, produced as described herein) is attached to a column and used to isolate the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein. Lysis and fractionation of *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein-harboring cells prior to affinity
- 25 chromatography are performed by standard methods (see, *e.g.*, Ausubel *et al.*, *supra*). In another example, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 proteins are purified or substantially purified from a mixture of compounds such as an extract or supernatant obtained from cells (Ausubel *et al.*, *supra*). Standard purification techniques can be used to progressively eliminate undesirable

compounds from the mixture until a single compound or minimal number of effective compounds has been isolated.

Once isolated, the recombinant protein can, if desired, be further purified, e.g., by high performance liquid chromatography (see, e.g., Fisher, *Laboratory Techniques In Biochemistry And Molecular Biology*, eds., Work and Burdon, Elsevier, 1980).

Polypeptides of the invention, particularly short *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein fragments, can also be produced by chemical synthesis (e.g., by the methods described in *Solid Phase Peptide Synthesis*, 2nd ed., 1984 The Pierce Chemical Co., Rockford, IL).

These general techniques of polypeptide expression and purification can also be used to produce and isolate useful *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein fragments or analogs (described herein).

Yatapoxvirus or *swinepox* virus (C1L) gp38 polypeptides can be attached to any one of a variety of tags. Tags can be amino acid tags or chemical tags and can be added for the purpose of purification (for example a 6-histidine tag for purification over a nickel column). Various labels can be used as means for detecting binding of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein to another protein, for example to a chemokine or a chemokine receptor.

Alternatively, *Yatapoxvirus* or *swinepox* virus (C1L) gp38 DNAs or RNAs may be labeled for detection, for example in a hybridization assay. *Yatapoxvirus* or *swinepox* virus (C1L) gp38 nucleic acids or polypeptides, or derivatives thereof, may be directly or indirectly labeled, for example, with a radioisotope, a fluorescent compound, a bioluminescent compound, a chemiluminescent compound, a metal chelator or an enzyme. Those of ordinary skill in the art will know of other suitable labels or will be able to ascertain such, using routine experimentation. *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptides can also be linked to toxins. Proteins linked to toxins can be used, for example to

target toxic drugs to malignant tumors if the protein has the ability localize to the tumor.

Anti-Yatapoxvirus or Anti-swinepox virus (C1L) gp38 Protein Antibodies

5 To generate *Yatapoxvirus* gp38 protein-specific antibodies, a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide coding sequence (e.g., gp38 from TPV, YMTV, or *swinepox* virus (C1L)) is expressed, for example, as a C-terminal fusion with glutathione S-transferase (GST) (Smith *et al.*, *Gene* 67:31-40, 1988). The fusion protein is then purified on glutathione-Sepharose beads, eluted with
10 glutathione cleaved with thrombin (at the engineered cleavage site), and purified to the degree necessary for immunization of rabbits. Primary immunizations are carried out with Freud's complete adjuvant and subsequent immunizations with Freud's incomplete adjuvant. Antibody titres are monitored by Western blot and immunoprecipitation analysis using the thrombin-cleaved *Yatapoxvirus* or
15 *swinepox* virus (C1L) gp38 protein fragment of the GST-*Yatapoxvirus* or *swinepox* virus (C1L) gp38 fusion protein. Immune sera are affinity purified using CNBr-Sepharose-coupled *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein. Antiserum specificity is determined using a panel of unrelated GST proteins and GST-trypsin (which was generated by PCR using known sequences).

20 As an alternate or adjunct immunogen to GST fusion proteins, peptides corresponding to relatively unique hydrophilic *Yatapoxvirus* or *swinepox* virus (C1L) gp38 proteins may be generated and coupled to keyhole limpet hemocyanin (KLH) through an introduced C-terminal lysine. Antiserum to each of these peptides is similarly affinity purified on peptides conjugated to BSA, and
25 specificity tested in ELISA and Western blots using peptide conjugates, and by Western blot and immunoprecipitation using *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein expressed as a GST fusion protein.

Alternatively, monoclonal antibodies may be prepared using the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 proteins described above and standard

hybridoma technology (see, *e.g.*, Kohler *et al.*, *Nature*, 256:495, 1975; Kohler *et al.*, *Eur. J. Immunol.* 6:511, 1976; Kohler *et al.*, *Eur. J. Immunol.* 6:292, 1976; Hammerling *et al.*, In *Monoclonal Antibodies and T Cell Hybridomas*, Elsevier, NY, 1981; Ausubel *et al.*, *supra*). Once produced, monoclonal antibodies are also
5 tested for specific *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein recognition by Western blot or immunoprecipitation analysis (by the methods described in Ausubel *et al.*, *supra*). Antibodies which specifically bind *Yatapoxvirus* or *swinepox* virus (C1L) gp38 proteins are considered to be useful in the invention; such antibodies may be used, *e.g.*, in an immunoassay to monitor the level of
10 *Yatapoxvirus* gp38 proteins produced by a mammal (for example, to determine the amount or location of a *Yatapoxvirus* or *swinepox* virus (C1L) gp38 protein).

Preferably, antibodies of the invention are not only produced using the whole *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide, but using fragments of the *Yatapoxvirus* or *swinepox* virus (C1L) gp38 polypeptide that lie
15 outside highly conserved regions and appear likely to be antigenic, by criteria such as high frequency of charged residues may also be used. In one specific example, such fragments are generated by standard techniques of PCR and cloned into the pGEX expression vector (Ausubel *et al.*, *supra*). Fusion proteins are expressed in *E. coli* and purified using a glutathione agarose affinity matrix as described in
20 Ausubel *et al.* (*supra*). To attempt to minimize the potential problems of low affinity or specificity of antisera, two or three such fusions are generated for each protein, and each fusion is injected into at least two rabbits. Antisera are raised by injections in a series, preferably including at least three booster injections.

Antibodies to *Yatapoxvirus* or *swinepox* virus (C1L) proteins can be used to
25 detect *Yatapoxvirus* or *swinepox* virus (C1L) proteins. In addition, the antibodies can be coupled to compounds, such as radionuclides and liposomes for diagnostic or therapeutic uses.

EXAMPLES

Cloning Additional Yatapoxvirus-Related gp38 Genes.

Standard techniques, such as the polymerase chain reaction (PCR) and DNA hybridization, can be used to clone *Yatapoxvirus-related* gp38 genes.

- 5 *Yatapoxvirus-Related* gp38 genes and homologs can be readily identified using low-stringency DNA hybridization or low-stringency PCR with specific probes or primers. Degenerate primers *Yatapoxvirus-related* gp38 amino acid sequences can be used to clone additional *Yatapoxvirus-related* gp38 genes and homologs by RT-PCR.

- 10 Based on the amino acid sequences provided by the present invention, degenerate oligonucleotide primers containing restriction sites are synthesized. First strand cDNA is synthesized from RNA prepared from a tissue of interest and PCR is performed with an initial five cycle step, for example, at 37°C for 60s, followed by 25 cycles at 50°C for 60s (denaturation at 95°C for 30s and extension
15 at 72°C for 90s) in order to amplify a *Yatapoxvirus-related* gp38 cDNA fragment that can be subsequently subcloned into Bluescript II KS (Stratagene). Construction of a cDNA library using poly A RNA isolated from the selected tissue is performed using Stratagene ZAP Express Vector according to the directions of the manufacturer. Potential clones are subsequently amplified and an
20 aliquot of this cDNA library containing phage is screened with the *Yatapoxvirus* gp38 cDNA that has been ³²P-labeled with Klenow enzyme. Isolated phagemids are subsequently subjected to automated sequencing on both strands using Applied Biosystems Instrumentation (model 373a) and the dye-terminator protocol. Sequence analysis is performed using software developed, for example, by the
25 University of Wisconsin genetics computer group (Altschul, *et al. J. Mol. Biol.* 215:403-410, 1990).

Yatapoxvirus gp38 mRNA Expression in Different Organs.

Northern blot analysis of total RNA isolated from different mammalian tissue samples is performed to detect expression of any *Yatapoxvirus* gp38 gene, homolog or derivative. Mammalian tissues including the brain, bone marrow, skin, intestines, stomach, heart, thymus, lymph node, mammary gland, skeletal muscle, tongue, spleen, liver, testes, and kidney are analyzed. Likewise, cell lines, such as macrophages isolated and cultured from the spleen, a lung epithelial cell line, and a colon adenocarcinoma cell, are analyzed for expression of *Yatapoxvirus* gp38 mRNA.

10 *DNA and RNA analysis.*

RNA is isolated by CsCl centrifugation in guanidine isothiocyanate (Chirgwin, *et al.* (1979) *Biochemistry*. 18:5294-9). Biologically active ribonucleic acid is isolated from sources enriched in ribonuclease. DNA is isolated from these gradients as well. In some cases, RNA is isolated using RNazol (Biotecx Lab, Inc.) according to the directions of the manufacturer. Poly A RNA is enriched by elution through an oligo dT column (Pharmacia). For example, 10 µg of total RNA, 2 µg of poly A RNA, or 10 µg of restriction endonuclease cut DNA is electrophoresed in agarose, and transferred to Gene Screen (NEN Dupont) membranes. Membranes will be hybridized with ³²P labeled full length cDNA or a fragment encoding the translated protein. High stringency hybridization is performed, for example, in 50% formamide, 10% dextran sulfate, 5X SSC, 1X Denhardt's solution (0.0002% (w/v) polyvinylpyrrolidone, 0.0002% (w/v) BSA, 0.0002% (w/v) Ficoll 400), 1% (w/v) SDS, 100 µg /ml denatured herring sperm DNA, and 20mM Tris at 42°C and blots are washed with 0.2X SSC, 0.5% SDS at 65°C. Low stringency hybridization is performed, for example, in 0.6M NaCl, 80mM TrisCl, 4mM EDTA, 0.1% (w/v) sodium pyrophosphate, 0.1% (w/v) SDS, 10X Denhardts, 100 µg /ml denatured herring sperm DNA at 50°C and washed

with 1XSSC, 0.05% SDS at 50°C. Quantitation of the intensity of band hybridization will be determined using a Phosphor-Imager (Molecular Dynamics).

Yatapoxvirus gp38 Gene Analysis.

5 A cDNA probe from the coding region of the *Yatapoxvirus* gp38 cDNA is ³²P-labeled with Klenow enzyme and used to screen approximately 1 X 10⁶ plaques from a mammalian genomic library (*e.g.*, a variety of libraries are available from Stratagene, La Jolla, CA) under conditions of low stringency (hybridization in 0.6 M NaCl, 80mM TrisCl, 4mM EDTA, 0.1% sodium
10 pyrophosphate, 0.1% SDS, 10X Denhardt's solution (0.002% polyvinylpyrrolidone, 0.002% BSA, 0.002% Ficoll 400), 100µg/ml denatured herring sperm DNA at 50°C and blots washed with 1X SSC, 0.05% SDS at 50°C). Plaques that hybridize strongly are purified. The genomic DNA is liberated from the phage DNA by restriction digestion with the appropriate enzymes and sub-cloned into
15 pBlue- Script SK II (Stratagene). Any positively identified genomic fragment that hybridizes with the probe is subcloned into, for example, pBlue-Script KS II, and subjected to automated sequencing on both strands using Applied Biosystems Instrumentation (model 373a) and the dye-terminator protocol. Sequence analysis is performed using software developed by, for example, the University of
20 Wisconsin genetics computer group Altschul *et al.*, *J. Mol. Biol.* 215:403-410, 1990.

 The *Yatapoxvirus* gp38 gene homolog chromosomal localization is determined by the analysis of any identified polymorphisms in the gene. PCR primers flanking this polymorphism will be constructed and genomic DNA is
25 amplified by PCR. Using these primers, a size polymorphism is identified (for example, see Rowe, *et al.*, *Mamm. Gen.* 5: 253-274, 1994).

 The identified genomic fragment can be used to screen a mammalian cDNA expression library (Stratagene) under conditions of high stringency (hybridization in 50% formamide, 10% dextran sulfate, 5X SSC, 1X Denhardt's solution, 1%

SDS, 100 mcg/ml denatured herring sperm DNA, and 20mM Tris at 42°C and blots were washed with 0.2X SSC, 0.5% SDS at 65°C). Positive plaques are identified, purified, and phagemids are prepared according to the instructions of the library manufacturer. The inserts are completely sequenced on both strands by automated sequencing. Alignment analysis will be determined by the Clustal method using MegAlign software (DNASTAR Inc) (Higgins, *et al.* (1988) Gene 73, 237-244), or other standard software.

Construction and Transfection of Protein Expression Vectors.

PCR primers are designed to amplify the coding region of the *Yatapoxvirus* gp38 gene, or homolog or derivative thereof, flanked by convenient restriction sites for subsequent sub-cloning. PCR is performed under standard conditions using *Yatapoxvirus* gp38 cDNA-pBlueScript as a template. The resulting PCR products are subsequently subcloned using, for example, a TA cloning kit (Invitrogen, San Diego, CA) and confirmatory sequencing is performed. *Yatapoxvirus* gp38 cDNA is subcloned into the available restriction sites of pcDNA-I/Amp (Invitrogen). Approximately 4 µg of the *Yatapoxvirus* gp38-pcDNA-I construct is transfected into 100 mm plates containing ~30% confluent COS cells using DEAE-Dextran (Lopata, *et al.*, *Nucl. Acids Res.* 12, 5707-5717, 1984). In order to measure transfection efficiency, a replicate sample of COS cells will be transfected with a CMV promoter-placental alkaline phosphatase control plasmid (Fields-Berry *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* 89: 693-697, 1992). RNA expression is confirmed by Northern analysis using the *Yatapoxvirus* gp38 cDNA as a probe. *Yatapoxvirus* gp38 -pcDNA-I transfected or mock transfected COS cell supernatant is obtained after 72 hrs of culture and stored at 4°C. In another set of transfection experiments, *Yatapoxvirus* gp38 cDNA is similarly subcloned into the available site of MoLTR-SV40 I/PA expression vector (for example, see Luster, *et al.*, *J. Exp. Med.* 178, 1057-1065, 1993). 20 µg of linearized *Yatapoxvirus* gp38-MoLTR construct and 1µg of

linearized neomycin resistance plasmid pSV7Neo is used to transfect J558L cells by electroporation. G418 resistant cells from single wells are analyzed for *Yatapoxvirus* gp38 mRNA expression by Northern analysis. Cells expressing *Yatapoxvirus* gp38 protein or control untransfected cells (that do not express

5 *Yatapoxvirus* gp38 protein) will be expanded in large cultures. In order to optimize the concentration of *Yatapoxvirus* gp38 protein in the supernatant, the cells are grown at high density (1×10^6 cells/ml) in RPMI without FCS, cultured for 72 hrs, and the conditioned medium is concentrated 5-fold with Centricon 3000 microconcentrators (Amicon, Beverly, MA) before being stored.

10 *Chemotaxis Assays.* Leukocytes, for example eosinophils, are isolated. Eosinophils, in particular, can be isolated from IL-5 transgenic mice (Dent, *et al.*, *J. Exp. Med.* 172:1425-1431, 1990). These mice develop splenomegaly, with eosinophils accounting for ~30% of the splenocytes. Eosinophils are purified from the spleen using immuno-magnetic separation to remove the contaminating

15 splenocytes. Briefly, splenocytes are labeled with anti-Thy-1 (M5/49), anti-B220 (6B2), and anti-Lyt-2 (53-6.7). Hybridoma cell lines are obtained, for example, from American Type Culture Collection and hybridoma cell supernatants are used as a source of antibodies. The antibody labeled cells are treated with anti- serum coated-magnetic beads, the anti-serum having specificity for the isotype of the

20 primary antibody, (M450, Dynal, Great Neck, NY), and eosinophils are enriched by negative selection through a magnetic field. Macrophage cells are isolated from the peritoneal cavity of mice that have been pre-treated (2 days prior) with intraperitoneal injection of 2.9% thioglycollate (Difco, Detroit, CA). Peritoneal neutrophils are isolated from mice pre-treated with sodium casein (Luo, *et al.*, *J.*

25 *Immun.* 153, 4616-4624, 1994). Macrophages and neutrophils are purified by Percoll gradients (Luo, *et al.*, *J. Immun.* 153, 4616-4624, 1994. Eosinophils or macrophages are suspended in HBSS with 0.05% BSA at 2×10^6 cells/ml, respectively, and 50 ml of replicate cells are placed in the top well of a 48 well micro-chemotaxis chamber (Neuro Probe, Inc, Cabin John, MD). A polycarbonate

filter with 5- μ m pores are used to separate the cells from buffer (30 ml) alone or buffer containing recombinant COS cell supernatant and a positive (for example MCP-1 (Rollins, & Pober, *Am. J. Path.*, 138, 1315-1319, 1991)) and negative control (for example, supernatant from mock-transfected COS cells) so that a comparison can be made and the immunosuppressive (inhibition of chemotaxis) properties of the *Yatapoxvirus* gp38 protein assessed. Cells are incubated at 37°C for 60 minutes (eosinophils and neutrophils) or 90 minutes (macrophages) and the cells that migrate across the filter and adhere to the bottom side of the filter are stained with Diff-Quick (Baxter Scientific, McGaw Park, IL). The number of cells per 400X field is counted.

Statistical Analysis. The statistical significance of differences between means is determined by analysis of variance (ANOVA). $P < 0.05$ is considered significant. When ANOVA indicates a significant difference, the Newman-Keuls test is used to determine which groups are significantly different from each other.

Other Embodiments

All publications and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each independent publication or patent application was specifically and individually indicated to be incorporated by reference.

While the invention has been described in connection with specific embodiments thereof, it will be understood that it is capable of further modifications and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure come within known or customary practice within the art to which the invention pertains and may be applied to the essential features hereinbefore set forth, and follows in the scope of the appended claims.

What is claimed is: